PATENT SPECIFICATION

826,810

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COMPLETE SPECIFICATION

DRAWINGS ATTACHED

Improvements in or relating to Electromagnetic Wave Guide Couplers

We, WESTERN ELECTRIC COMPANY INCORPORATED, of 195, Broadway, New York City, New York State, United States of America, a Corporation of the State of New York, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to electromagnetic wave guide couplers and particularly to wide-band directional couplers for wave guides.

An object of the invention is to flatten the transmission band of a wave-guide directional coupler. Another object is to reduce the transmission loss in the band of such a coupler. A further object is to discriminate against another selected band of frequencies.

In microwave systems, it is sometimes desired to connect two wave guides through a directional coupler which has a wide, flat transmission band and a selected rejection band. Such a coupler is useful, for example, in an arrangement for connecting two wave guides, carrying different frequency bands, to a single guide which feeds a common antenna.

The wave guide coupler in accordance with the present invention is well suited to meet these requirements. It comprises two hollow wave guides arranged side by side and having a common wall with one or more coupling apertures therein. A resonant obstacle is associated with each aperture. This resonant obstacle is antiresonant at a selected frequency f_A outside a band of frequencies to be transmitted from one of the guides to the other and is so coupled to the electromagnetic field in its associated aperture that the transmission loss through the aperture is lowered over the said band of frequencies. When the coupling aperture is circular, the resonant obstacle may be a conductive ring having an outer circumference approximately equal to an integral number n of free-space wavelengths λ at f_A. The inner diameter is chosen to make the desired transmission band as flat as possible. For a coupling slot, the resonant obstacle is preferably a bent, conductive rod having a length approximately equal to $n\lambda/4$ at f_A. One or both ends of the rod are connected to a side of the slot. The point of connection and the diameter of the rod largely determine the flatness of the transmitted band.

The invention will be more fully understood from the following detailed description of two typical embodiments thereof with reference to the accompanying drawings, in which:

Fig. 1 is a perspective view of two wave guides coupled through apertures with rod-type resonant obstacles in accordance with the invention;

Fig. 2 shows an embodiment in which the resonant obstacles are conductive rings;

Fig. 3 is a cross section of one of the rings used in Fig. 2; and

Fig. 4 shows typical loss characteristics of the coupler obtainable, respectively, with and without the resonant obstacles.

The coupling arrangement shown in Fig. 1 is formed by two rectangular waveguides 4 and 5 arranged side by side. The waveguide 5 is of square cross-section and is formed with four walls. The waveguide 4 is of rectangular cross-section with unequal transverse dimensions and is formed by securing a structure having three walls to the wall 6 of the waveguide 5 so that the wall 6 also forms the fourth wall of the waveguide 4. The wall 6 is thus common to both waveguides and is herein referred to as the common wall. For maximum energy transfer, both guides will have the same velocity of

[Price 3s. 6d.]

propagation in the transmission band.

In practising the invention, one or more apertures, such as 7, are provided in the common wall 6. Four such apertures are shown, but it will be understood that any number may be employed, depending upon the amount of energy to be transferred. If directional properties are desired in the coupler, the centres of the apertures preferably have a spacing approximately equal to an odd integral number of quarter-wavelengths in the guides at a frequency to be transmitted. This spacing will provide a good input impedance and high directivity, but is not critical.

In Fig. 1, each aperture 7 is in the form of a slot with its length parallel to the longitudinal axes of the guides 4 and 5. Associated with each slot 7 is a resonant obstacle, coupled to the electromagnetic field therein. As shown, the resonant obstacle is a conductive rod 9, with a right-angle bend near one end thereof and conductively attached at the said one end to an upper side of the first slot 7. These rods project alternately from opposite sides of the slots 7, thus in the slot designated 8 the conductive rod is connected to the lower side of the slot. This provides mechanical and electrical symmetry and thus avoids conversion from vertical to horizontal polarization in the square guide 5.

Electromagnetic waves may, for example, be fed into the guide 4 at one end, as indicated by the arrow 10. The electric field of these waves is perpendicular to the wider walls of the guide, as shown by the arrow E. It will be assumed that it is desired to transfer a wide band, centred at the frequency f_B, from the guide 4 to the guide 5 and to propagate these waves in the latter in the direction of the arrow 11. It will also be assumed that it is desired to exclude a higher band of frequencies, centred at a selected frequency f_A, from the guide 5.

If the resonant obstacles were omitted, the coupling loss, in decibels, from the guide 4 to the guide 5 over the frequency range from 3.6 to 6.8 kilomegacycles per second would, in a typical case, be of the form shown by the curve 12 in Fig. 4, in which the ordinate represents the coupling loss and abscissa the range of frequencies. In the region of interest, this loss increases with frequency, and the slope is steepest at the lower end, near the cut-off frequency of the guide 4.

To suppress the band centred at f_A, the length of the rod 9 and by the point at which it is connected to the side of the slot 7. The closer this point of connection is to the centre of the slot 7, the wider is the suppressed band. Decreasing the diameter of the rod reduces the width of the band. If the length of the rod is made equal to an integral number of half-wavelengths, then both ends of the rod should be connected to one side of the slot 7, the rod extending along the length of the slot.

The point of connection and the diameter of the rod may be so chosen that the transmission loss through the slot 7 is made lower and more uniform in the band centred at f_B. The curve 13 in Fig. 4 shows a typical characteristic obtainable. This is a measured characteristic for a directional coupler having 16 coupling slots, each 0.715 of an inch in length, and 16 resonant rods, each 0.032 of an inch in diameter and 0.445 of an inch in length and offset from the side of the slot by 0.125 of an inch. A comparison of the curves 12 and 13 shows that, for a band centred at a frequency f_B of 4.2 kilomegacycles per second, the addition of the rods reduces the loss by approximately three decibels. It will also be noted that there is a second quite flat band centred at the frequency F_C over which the loss is even lower than at f_B.

Fig. 2 shows a directional coupler with circular coupling holes 15 in the common wall 16 between the wave guides 4 and 5. As shown more clearly in the cross-sectional view of Fig. 3, a dielectic ring fits into each of the holes 15. Inside of the ring 17 is a conductive ring 18. The rings 17 and 18 are held in place by two strips of insulating material 19 and 20 placed on opposite sides of the wall 16 and fastened thereto by any suitable means. In Fig. 2, part of the strip 20 has been broken away to show the first hole 15 and the rings 17 and 18. In order to provide a coupling characteristic such as curve 13, with high loss at f_A, the outer circumference of the ring 18 is made approximately equal to $n\lambda$ at that frequency. The width of the suppressed band and the shape of the characteristic at other frequencies are determined largely by the inner diameter D of the ring 18. As the inner diameter D is made smaller, the suppressed band becomes wider. The presence of the dielectric ring 17 and strips 18 and 19 in effect slightly increases both the inner and the outer diameter of the conductive ring 18, and thus affects the shape of the curve to an extent depending upon the dielectric constant of the material used.

It is to be understood that the above-described embodiments have been described merely by way of example and may be modified in various ways by those skilled in the art within the scope of the invention as defined by the appended claims.

WHAT WE CLAIM IS:—

1. An electromagnetic wave guide coupler comprising two hollow wave guides arranged side by side and having a common wall with one or more coupling apertures therein and a resonant obstacle associated with each of the apertures, the resonant obstacle being dimensioned to be antiresonant at a selected frequency outside a band of fre-

quencies to be transmitted from one of the guides to the other and being so coupled to the electromagnetic field in its associated aperture that the transmission loss through the aperture is lowered over the said band of frequencies.

2. A wave guide coupler as claimed in claim 1, provided with a series of coupling apertures positioned along the length of the common wall, in which the spacing between the centres of the apertures is approximately equal to an odd integral number of quarter-wavelengths in the guides at a frequency inside the said band of frequencies.

3. A wave guide coupler as claimed in claim 1 or claim 2, in which the coupling aperture or each coupling aperture is a slot with its length parallel to the longitudinal axes of the wave guides, and the resonant obstacle is a conductive rod positioned within and attached to a boundary surface of the slot.

4. A wave guide coupler as claimed in claim 3, in which the conductive rod is bent at a right angle adjacent one end thereof and is attached at the said one end to a side of the slot so as to extend along the length of the slot.

5. A wave guide coupler as claimed in claim 4, in which the conductive rod has a length approximately equal to an integral number of free space quarter-wavelengths at the selected frequency.

6. A wave guide coupler as claimed in claim 3, in which the conductive rod is bent at a right angle adjacent both ends thereof and is attached at both ends to a side of the slot so as to extend along the length of the slot.

7. A wave guide coupler as claimed in claim 6, in which the conductive rod has a length approximately equal to an integral number of free space half-wavelengths at the selected frequency.

8. A wave guide coupler as claimed in any of claims 3 to 7 provided with a series of slots positioned along the length of the common wall and each containing a conductive rod, in which the rods in the successive slots of the series are attached respectively to sides thereof which are opposite in the successive slots.

9. A wave guide coupler as claimed in any of claims 3 to 8, in which the diameter of the conductive rod or each conductive rod and its point or points of attachment to the side of its associated slot are selected so as to flatten the transmission loss through the slot.

10. A wave guide coupler as claimed in claim 1 or claim 2, in which the coupling aperture or each coupling aperture is circular, and the resonant obstacle is a conductive ring positioned within the aperture.

11. A wave guide coupler as claimed in claim 10, in which the conductive ring is mounted inside a dielectric ring fitted into the aperture.

12. A wave guide coupler as claimed in claim 10 or claim 11, in which the conductive ring has an outer circumference approximately equal to an integral number of free space wavelengths at the selected frequency.

13. A wave guide coupler as claimed in any of claims 10 to 12 provided with a series of circular apertures positioned along the length of the common wall and each containing a conductive ring, in which the conductive rings (and the dielectric rings, if present) are held in place by strips of insulating material attached to opposite sides of the common wall.

14. A wave guide coupler as claimed in any of claims 10 to 13, in which the inner diameter of the conductive ring or each conductive ring is selected so as to flatten the transmission loss through its associated aperture.

15. A wave guide coupler as claimed in any of claims 1 to 14, in which both wave guides have the same velocity of wave propagation in the said band of frequencies.

16. An electromagnetic wave guide directional coupler constructed and adapted to operate substantially as herein described with reference to Fig. 1 of the accompanying drawings.

17. An electromagnetic wave guide directional coupler constructed and adapted to operate substantially as herein described with reference to Figs. 2 and 3 of the accompanying drawings.

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826,810 COMPLETE SPECIFICATION
1 SHEET This drawing is a reproduction of the Original on a reduced scale.

Fig.1.

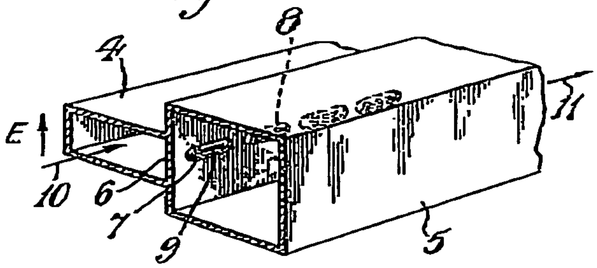

Fig.2.

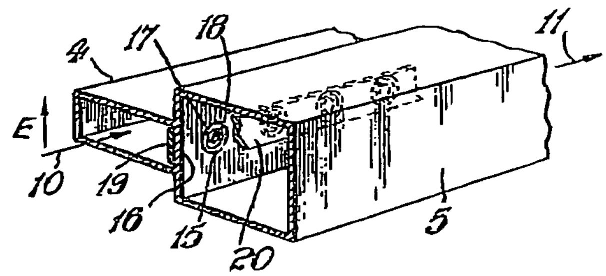

Fig.3.

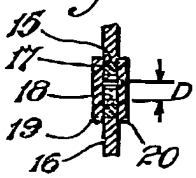

Fig.4.